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The Affecting Factors of Touch DNA

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Abstract

Touch DNA, trace DNA or Low copy number has become an area of interest in recent years because of its importance when other type of biological evidences might not be available. However, minimal efforts have been devoted to develop the collection methods of touch DNA, and the success of DNA typing depends on the availability of existing DNA templates. In most cases DNA leaves sufficient quantity and quality of genomic DNA to produce a DNA profile. However, some variables affect the success of obtaining a good quality DNA profile. Such variables include shedder status, surface type, pressure of contact; other variables include the methods of DNA collection and the methods of DNA extraction.

Keywords: DNA typing; DNA analysis; Touch DNA; Genetic markers

Introduction

Over the years, considerable technological development toward DNA typing in the bid to identify genetic markers has been undertaken. However, minimal efforts have been devoted to the determination of the end of the process. This is despite the fact that the procedure of DNA collection and recovery remains the most critical in the process of DNA analysis. Almost all assays demand sufficient amount of DNA both quantitatively and qualitatively. So, the success of DNA typing depends on the availability of existing DNA templates. Better methods are required to recover DNA, especially when addressing the most challenged samples such as touch DNA.

Although a number of previous studies are delving into the effectiveness of the different method of DNA recovery from body fluids [1,2] there is a gap in published data focusing on trace DNA [3], and incorporation of recovery as well as extraction efficiencies are vital steps in the interpretation of trace DNA [4].

There are various methods of collecting trace DNA, and many forensic labs have developed their methodologies entailing the collection process of touch DNA from different kind of surfaces. However, there is limited data in this field to share the knowledge, and most of the forensic DNA labs are still using cotton swabs to collect touch DNA from different types of surfaces. In most cases, use of cotton swabs results in loss of DNA [5]. Raymond et al. [6] conducted a study on the success rates of trace DNA identified that out of 252 trace casework samples from surfaces touched by hands, 44% did not produce a profile. Additionally, Castella and Mangin [7] conducted a study that indicated that out of 1739 contact traces from real casework samples; only 26% had a DNA profile suitable for entry into the Swiss DNA database.

DNA can be transferred to an object in many ways and one of them is by touching. Touch DNA, trace DNA or Low copy number has become an area of interest in recent years because of its importance when other type of biological evidences might not be available. In most cases, touch DNA leaves sufficient quantity and quality of genomic DNA to produce a DNA profile. However, some variables affect the success of obtaining a good quality DNA profile. Such variables include shedder status, surface type, and pressure of contact [8,9]. Other variables include the methods used in DNA collection [2] and the methods used in DNA extraction [10].

Touch DNA

Touch DNA refers to the transfer of DNA through skin cells when an object is either touched or handled. Over the last two decades, the process of obtaining DNA profile from touch has gained attention of the forensic scientists. This is an attempt to push the frontiers of the amount of information that can be derived from a minute amount of trace of DNA evidence such as those deposited by a fingerprint.

Van Oorschot and Jones [11] were the first to report the ability to recover DNA sample from epithelial cells from a handled object in 1997. This increased the possibilities of using DNA evidence in different cases, including on sexual assaults, rapes, and murder, where previously DNA recovery had not been tried or considered [12].

Since then, there are numerous research studies available in the literature where DNA has been expounded to be recovered from handled items. Such items include handbags, clothing, jewelry, weapons, and car steering wheels [13-19].

The quality and quantity of DNA deposited on an object determines the ability to recover the DNA evidence from the same. The amount of DNA deposited is not constant due to some reasons as discussed below.

Shedding Status

The amount of DNA deposited and its suitability for analysis is determined by the DNA deposition process. Additionally, the DNA deposition process is affected by some factors. These factors include the propensity of the individuals shedding the DNA, the activities the individual was involved in before the DNA deposition, the nature of the surface from which the DNA was recovered, and the quality of the physical contact of the DNA deposition [20-24]. Previous studies have

pointed out that some individuals may be considered "good shedders" when compared to others, someone who tends to lose or shed skin cells at a greater rate than others. Lowe et al. [20] classified individuals with a tendency to slough or shed their skin cell easily as compared to others as "good shedders." This was however contradicted by Phipps and Petricevic [22] in their study. The two argued that it was not possible to tell whether an individual was a good or bad shedder since different shedding tests on the same individuals under different circumstances and conditions showed different results.

Other factors that determine the shedding status of an individual includes the habits of a person. For instance, Phipps and Petricevic [22] argued that persons with habits of touching their face, eyes, nose, hairs, etc. are more likely to pick up DNA from those areas and transfer to other objects through touch. Wickenheiser [25] characterised this process as "loading" the fingers with DNA. Similarly, Tobias et al. [8] argued that increasing the pressure of the direct skin on a surface during a contact significantly increases the amount of DNA deposited on such an object regardless of the DNA deposition ability of an individual.

Type of Surface on which DNA is Deposited

According to Wickenheiser [25], a rough, porous surface for example wood has more ability to retain DNA than smooth, nonporous surfaces such as plastic. This can be attributed to abrasive nature of a rough surface which is likely to dislodge cells and therefore increasing chances of DNA retention. Contrary to this, Pesaresi et al. [26], indicated that smooth and nonporous surfaces such as glasses has higher chances of retaining more DNA than rough, porous surfaces such as untreated wood. This was attributed to the fact that smooth and nonporous surfaces increase the rate of perspirations during the interaction, and therefore increasing the amount of DNA deposited.

Wickenheiser [25], argued that although it is true that more DNA was likely to be deposited on the rough and porous surface, the amount of DNA that can be recovered from such surfaces was lower and that might be because of ineffective recovery processes from the rough surface. However, Goray et al. [9] showed that the amount of DNA that can be retrieved from a cotton substrate (rough surface) on average is 11.68 ng. This was significantly higher as compared to the amount of DNA extracted from plastic (smooth surface), 0.4 ng. This implies that there is a higher preferential DNA deposition on the rough surface. This means that the DNA persistence is higher on porous primary substrates, which are likely to surrender the deposited DNA more easily than non-porous surfaces. However, the pitfall of above studies is all the above studies were based on small sample size, and therefore further work is needed considering a larger sample size.

In relation to crime case investigations, there are studies in many publications about the DNA being recovered from handled items [27-29]. However the actual success rate may vary based on sample type, for example, Williams and Johnson [30] reported that around 18% of samples collected from watch straps were successfully profiled by the Forensic Science Service (FSS). The general idea is that caution must be heeded when DNA analysis used to determine if an individual has handled an item, because surface type may play an important role on the amount of DNA deposited.

The Time between Deposition and Recovery

Fregeau et al. [31], noticed that the amount of DNA recovered from a fresh touch was higher than the amount of DNA recovered from a touch that has been stored over a long period of time. Murray et al. [32] would later add that it was possible to retrieve a full DNA profile from the plastic tube after a ten-second contact by a good shedder after four months when kept at room temperature. However, there was a significant decrease in the amount of DNA that was recovered from a poor shedder. As such, the time between deposition and the collection of DNA was a substantial factor for the amount of DNA recovered. This was in agreement to Bille et al. [33] where it was concluded that there was a decrease in the amount of DNA recovered between samples collected and analysed within seven days (average 0.34 ng/µl) compared to a sample collected and analysed within ninety days (average 0.038 ng/µl). Similarly, Raymond et al. [34] pointed out that the DNA deteriorated with the advance in time. However, the rate of deterioration highly depends on the conditions the touched object is exposed to. In the same vein, Li and Harris [35] argued that the possibility of having a DNA sample contaminated was less over a short time interval. These studies concluded that minimising the time taken for the DNA collection is a crucial factor in ensuring a higher DNA yields.

Environmental Factors

An experimental study conducted in Australia showed that it was possible to obtain interpretable DNA profiles from an outside surface, such as a window frame recovered two weeks after deposition [at an average temperature and relative humidity were 24.1°C, 63% (day) and 18°C, 71% (night)], and a DNA profile from a glass slide stored in a cold and dark place for up to six weeks since deposition [36]. The difference in the lifetime in both cases was attributed to environmental factors such as high temperature, humidity, and exposure to UV-light, as weather conditions and moisture surrounding the surface can impact on the likelihood of DNA persistence.

A DNA sample in a damp environment is susceptible to hydrolytic cleavage and oxidation base damage. The primary target of hydrolytic cleavage is the base sugar bond, which results in loss of the base through depurination and nicking of the entire DNA [37]. Increase in heat leads to a rise in the rate of hydrolytic cleavage. Consequently, this leads to direct cleavage of the DNA strands due to drying [37]. Similarly, oxidation damages the DNA by oxidizing the carbon bonds in pyrimidines and imidazole rings in purines leading to fragmentation of the ring [38]. Also, the UV irradiation of DNA (e.g., sunlight) leads to cross-linking of the adjacent thymine nucleotides, hindering the passage of the DNA polymerase during PCR [38]. Raymond et al. [36] showed reduced traces of biological material in samples exposed to the humid environment over time due to reduced environmental attritions. Although moisture in a sample can lead to increased rate of degradation, it may also enhance DNA transfer. A study by Goray et al. [9] on non-absorbent primary substrate such as plastic, indicated that only 4.2% of the total DNA available is carried over when dry biological samples are being transferred from one surface to another, while around 50%-95% of a sample is moved when the source of the sample is moist.

Type of Sampling Method Employed

Different methods can be used to recover DNA deposited through touch. These include mini-taping, swabbing, cutting out the area of interest for direct extraction or amplification; the method used in such a process is determined by the surface from which the DNA is to be recovered from [12]. DNA recovery process from solid and smooth surfaces is commonly done using wet and dry swabs [39]. For other

surfaces such as fabric, glass, and woods, mini-tapes can be used [40]. Verdon et al. [41] suggested that the type of sampling devices selected determine the success of the DNA collection and extraction. Another survey by Van Oorschot et al. [5] indicated that a significant amount of DNA is wasted while using cotton swabs as it retains some DNA (24% and 52% of 100 ng in the 100 µl extract was recovered when using dry and wet swabs technique). As a result, a lot of improvements are needed in the bid to develop the best method of DNA recovery.

In their study, Hansson et al. [42] made a comparison of Scene safe FAST™ minitape (Scene safe, UK) and three swabs types including cotton, flocked and foam. The study found out that use of tape was more efficient (concentration of recovered DNA; 0.1 ng/µl-0.48 ng/µl) than the use of any of the three swabs (concentration of the recovered DNA; 0.0 ng/µl-0.075 ng/µl) when touch DNA was recovered from a single type of cotton shirt material. It would be useful to expand the existing knowledge of the influence of sampling methods in recovering touch DNA, by doing a comparison study of the different collection methods of touch DNA from a different set of surfaces.

The Efficiency of Extraction of DNA from Sample

Typically, the process of DNA profiling starts with extraction of DNA from the substrate. The technique used in the mining determines the efficiency of the process. Some of the most superior extraction methods include 5% Chelex which outperformed organic methods in recovering DNA sample from heels and toes [43]. In addition, the DNeasy® plant mini kit (QIAGEN®) when compared with the QIAamp® mini kit, was found to enhance DNA recovery from paper by over 150% [18]. The nature of substrate from which the DNA has been recovered could have an influence on DNA extraction [40]. In their study of the performance of five extraction methods, Ip et al. [10] demonstrated using serially diluted blood and 76 simulated touch DNA sample, found that QIAamp® DNA Investigator Kit, QIAsymphony® DNA Investigator® Kit, and DNA IQ™ yielded extracts with a higher success rate for the subsequent DNA typing analysis, as compared to Chelex®100 and QIAamp® DNA Blood Mini Kit even after using Microcon to reduce their concentration.

On the other hand, the DNA extraction process can result in a loss of about 20% to 90% of the initial template amount depending on the extraction method used, as well as the accuracy of the quantification method [44,45]. The current purification step used in forensic DNA casework is time-consuming and labor-intensive. Also, the column-based methods used in purification result in loss of DNA, and therefore affecting successful typing of the low copy or degraded samples [46,47]. Use of direct PCR amplification has been suggested as one of the methods that can be used to prevent loss of DNA from touch evidence samples [48,49]. By skipping the extraction, quantification, and concentration processes, most quantities of DNA can be aimed, laboratory personnel error and DNA contamination from handling may be minimized and overall time of sample processing and cost could be reduced. There are some studies regarding the sampling methods for direct PCR amplification, for example an experiment by Ambers et al. [50] regarding touch DNA using; computer keyboards, door handles, computer mousses, cell phones and a necklace, concluded that microFLOQ® swab can obtain a full DNA profiles from a different type of surfaces. However, the amount of material available and the type of surface will affect the likelihood of success, similarly to the collection of any evidence by swabbing. The microFLOQ® Direct swabs fibres are regulated in the same manner as 4N6 FLOQSwabs® but are processed with a lysing agent for direct amplification, to eliminate the DNA extraction and quantification steps [50].

Conclusion

When collecting Touch DNA the use of different collection methods such as minitapes or different swab tip types can have a direct impact on the quantity of collected DNA, which is ultimately collected from a crime exhibit. On the other hand, the type of surface from which the samples are retrieved can have a direct effect upon the efficiency of certain collection method. It is recommend that laboratories and crime scene teams revaluate the methods and materials with which they collect touch samples from to produce the best possible profiling result. Also, more works need to be done to evaluate the affecting factors of touch DNA, and internal validation is needed to choose the most suitable collection methods for different kind of surfaces.

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